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MASTER

# COAL DESULFURIZATION BY A MICROWAVE PROCESS

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TECHNICAL PROGRESS REPORT

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## EXPERIMENTAL RESULTS

Desulfurization experiments were carried out using the 6 KW, 2450 MHz Flow Reactor System described in the March 1981 Progress Report. The program has been directed toward the combination of physical separation and microwave exposure with NaOH to increase sulfur removal. The following treatment sequence has been used with good results:

Step 1. Expose 1/4-1" raw coal to microwaves.

Step 2. Crush the treated coal and separate the sample into float/sink fractions.

Step 3. Add NaOH to the float fraction and re-expose the sample to microwaves.

Step 4. Wash, add NaOH and expose to microwaves.

This procedure has produced up to 89% sulfur removal and as low as .31 #S/$10^6$ BTU. Ash analyses on these samples showed as high as 40% reduction. The calorific value was increased in almost all samples.

The geographic origin of the coals used in these experiments is listed below:

| PSOC # | |
|---|---|
| 345 | Lower Kittanning Seam, PA |
| 255 | Lower Kittanning Seam, PA |
| 270 | American Seam, Quinton, AL |
| 272 | Kentucky #9 Seam, KY |

Table 1 summarizes data on sulfur, ash and calorific values. Sulfur forms* analyses were performed on a number of the runs listed in Table 1. These data are shown in Table 2.

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* The sulfur forms analysis was performed by Smith, Rudy & Company, Analytical Chemists, Phila., PA.

TABLE 1. SUMMARY OF SULFUR, ASH AND CALORIFIC VALUE ANALYSES
6 KW, 2.45 GHz FLOW REACTOR EXPERIMENTS

| PSOC # | RUN # | TOTAL SULFUR WT % | | | | | CALORIFIC VALUE | #S/$10^6$ | % ASH | % S LOSS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Raw Coal | Microwave | Float/ Sink Crush | Float | NaOH + MW | Btu/# Dry | Btu | | |
| 255 | 383* | 2.45 RAW COAL | | | | | 12385 | 1.93 | 19.4 | |
| (LOWER KITTANNING SEAM, PA) | 379 | | 1.89 | | 1.17 | | | | | |
| | 380 | | | | | .73+ | 14226 | 0.43 | 5.13 | 70.2 |
| | 414* (DT RUN 380) | | | | | .27+ | | | | 89.0 |
| | 399* | 2.12 RAW COAL | | | | | 12253 | 1.73 | 20.37 | |
| | 400 | | 1.75 | | 1.06 | | | | | |
| | 405* | | | | | .70+ | 13092 | 0.53 | 11.89 | 67.0 |
| | 418* (DT RUN 405) | | | | | .46+ | | | | 78.3 |
| | 402 | | 1.81 | | 1.16 | | | | | |
| | 406 | | | | | .70+ | | | | 67.0 |
| 270 | 398* | 2.66 RAW COAL | | | | | 12234 | 2.17 | 18.80 | |
| (AMERICAN SEAM, ALA) | 397 | | 1.58 | | 1.50 | | | | | |
| | 401* | | | | | .72+ | 13351 | 0.59 | 7.48 | 72.9 |
| | 417* (DT RUN 401) | | | | | .44+ | 13998 | 0.314 | | 83.5 |
| | 420 | 1.39 RAW COAL | | | | | | | | |
| | 419 | | 1.38 | | 1.40 | | | | | |
| | 421 | | | | | 1.10+ | | | | 20.9 |

* SULFUR FORMS ARE GIVEN IN TABLE 2. + HCL WASH BEFORE SULFUR ANALYSIS DT = REPEAT ALKALI + MW EXPOSURE

(CONT'D)

TABLE 1. SUMMARY OF SULFUR, ASH AND CALORIFIC VALUE ANALYSES
6 KW, 2.45 GHz FLOW REACTOR EXPERIMENTS

| PSOC # | RUN # | TOTAL SULFUR WT % | | | | | CALORIFIC VALUE | #S/10$^6$ | % ASH | % S LOSS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Raw Coal | Microwave | Float/ Sink Crush | Float | NaOH + MW | Btu/# Dry | Btu | | |
| 345 | 382* | 3.14 RAW COAL | | | | | 14050 | 2.23 | 7.3 | |
| (LOWER KITTANNING SEAM, PA) | 381 | | 2.24 | | | | | | | |
| | 410 (DT 381) | | 1.16 | | | | | | | 63.1 |
| | 386* | 4.26 RAW COAL | | | | | 13957 | 3.05 | 8.82 | |
| | 385 | | 3.26 | | | | | | | |
| | 389 | | | | | 1.62+ 1.82 | 13935 | 1.16 | 5.73 | 62.0 |
| | 415* (DT 389) | | | | | .59+ | 13300 | 0.444 | | 86.2 |
| | 392* | 2.03 RAW COAL | | | | | 13840 | 1.47 | 8.20 | |
| | 391 | | 2.68 | | 1.75 | | | | | |
| | 393 | | | | | 1.17+ | 14634 | 0.80 | 3.50 | 42.4 |
| | 416* (DT 393) | | | | | .51+ | 13663 | 0.373 | | 74.9 |
| | 403 | 3.04 RAW COAL | | | | | | | | |
| | 404 | | 2.84 | | 1.86 | | | | | |
| | 407 | | | | | 1.36+ | | | | 55.3 |
| | 382 | 3.14 RAW COAL | | | | | | | | |
| | 384 | | | | | 1.34 | | | | |
| | 409* (DT 384) | | | | | .50+ | | | | |

( CONT'D )

TABLE 1. SUMMARY OF SULFUR, ASH AND CALORIFIC VALUE ANALYSES
6 KW, 2.45 GHz FLOW REACTOR EXPERIMENTS

| PSOC # | RUN # | TOTAL SULFUR WT % | | | | | CALORIFIC VALUE | #S/$10^6$ | % ASH | % S LOSS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Raw Coal | Microwave | Float/ Sink Crush | Float | NaOH + MW | Btu/# Dry | Btu | | |
| 272 (KENTUCKY #9) | 412 | 4.05* RAW COAL | | | | | | | | |
| | 411 | | 2.84 | | 2.65 | | | | | |
| | 413 | | | | | 2.21+ | | | | 45.4 |

TABLE 2. SULFUR FORMS ANALYSES ON RAW AND MICROWAVE TREATED COAL SAMPLES


# SMITH, RUDY & COMPANY

ANALYTICAL

CHEMISTS

20 NORTH THIRD STREET

PHILADELPHIA, PA. 19106


May 13,1981

General Electric Company
R.E.S.D.
Philadelphia, Pa.

P.O.#P 65939

ANALYSIS OF COAL (Raw Samples)

| Sample Identification | Moisture | Tot.Sul. | Pyritic Sul. | Organic Sul. | Sulfate Sul |
|---|---|---|---|---|---|
| Run #382 | 1.51 | 2.93 | 1.54 | 1.19 | .20 |
| Raw Coal PSOC 345 | Dry | 2.97 | 1.56 | 1.21 | .20 |
| 3/8-1" | | | | | |
| Run #383 | 1.06 | 2.33 | 1.19 | .86 | .28 |
| Raw Coal PSOC 255 | Dry | 2.35 | 1.20 | .87 | .28 |
| 1/4-3/8" | | | | | |
| Run #386 3/13/81 | 1.79 | 4.16 | 2.69 | 1.10 | .37 |
| Raw Coal #345 | Dry | 4.24 | 2.74 | 1.12 | .38 |
| 1/4-1/2" | | | | | |
| Run #392 3/27/81 | 1.51 | 1.99 | .89 | .99 | .11 |
| Raw Coal #345 Coal | Dry | 2.02 | .90 | 1.01 | .11 |
| 30-200 m | | | | | |
| Run #398 4/1/81 | 1.30 | 2.55 | 1.29 | .92 | .34 |
| PSOC 270 Coal | Dry | 2.58 | 1.31 | .93 | .34 |
| Raw Coal 3/8-1" | | | | | |
| Run #399 4/1/81 | .83 | 1.91 | 1.03 | .88 | .00 |
| PSOC 255 | Dry | 1.93 | 1.04 | .89 | .00 |
| Raw Coal 3/8-1" | | | | | |

SMITH, RUDY & COMPANY

By _____

(CONT'D)

TABLE 2. SULFUR FORMS ANALYSES ON RAW AND MICROWAVE TREATED COAL SAMPLES


# SMITH, RUDY & COMPANY

ANALYTICAL

CHEMISTS

20 NORTH THIRD STREET

PHILADELPHIA, PA. 19106


May 13, 1981

General Electric Company
R.E.S.D.
Philadelphia, Pa.

P.O.#P 65939

ANALYSIS OF COAL (Treated Samples)

| Sample Identification | Moisture | Tot. Sul. | Pyritic Sul. | Organic Sul. | Sulfate Sul. |
|---|---|---|---|---|---|
| Run #414 4/16/81 | 9.51 | .24 | .00 | .22 | .02 |
| #255 Coal + NaOH Treated | Dry | .27 | .00 | .25 | .02 |
| Rerun of #380 HCL Wash | | | | | |
| Run #415 4/16/81 | 11.40 | .51 | .00 | .47 | .04 |
| 345 Coal + NaOH | Dry | .58 | .00 | .53 | .05 |
| Rerun of 389 HCL Wash | | | | | |
| Run #416 | As Rec'd | .43 | .00 | .43 | .00 |
| #345 Coal + NaOH Treated | | | | | |
| Rerun of 393 HCL Wash | | | | | |
| Run #417 4/17/81 | 7.98 | .42 | .00 | .00 | .00 |
| #270 Coal + NaOH Treated | Dry | .46 | .00 | .00 | .00 |
| Rerun of Run 401 HCL Wash | | | | | |
| Run #418 4/17/81 | 5.13 | .40 | .00 | .40 | .00 |
| #255 Coal + NaOH Treated | Dry | .42 | .00 | .42 | .00 |
| Rerun of Run 405 | | | | | |
| Run #401 4/15/81 | As Rec'd | .61 | | | |
| Run #405 4/15/81 | As Rec'd | .52 | | | |
| Run #409 | As Rec'd | .51 | | | |
| Rerun of 384 | | | | | |

SMITH, RUDY & COMPANY

By [illegible]

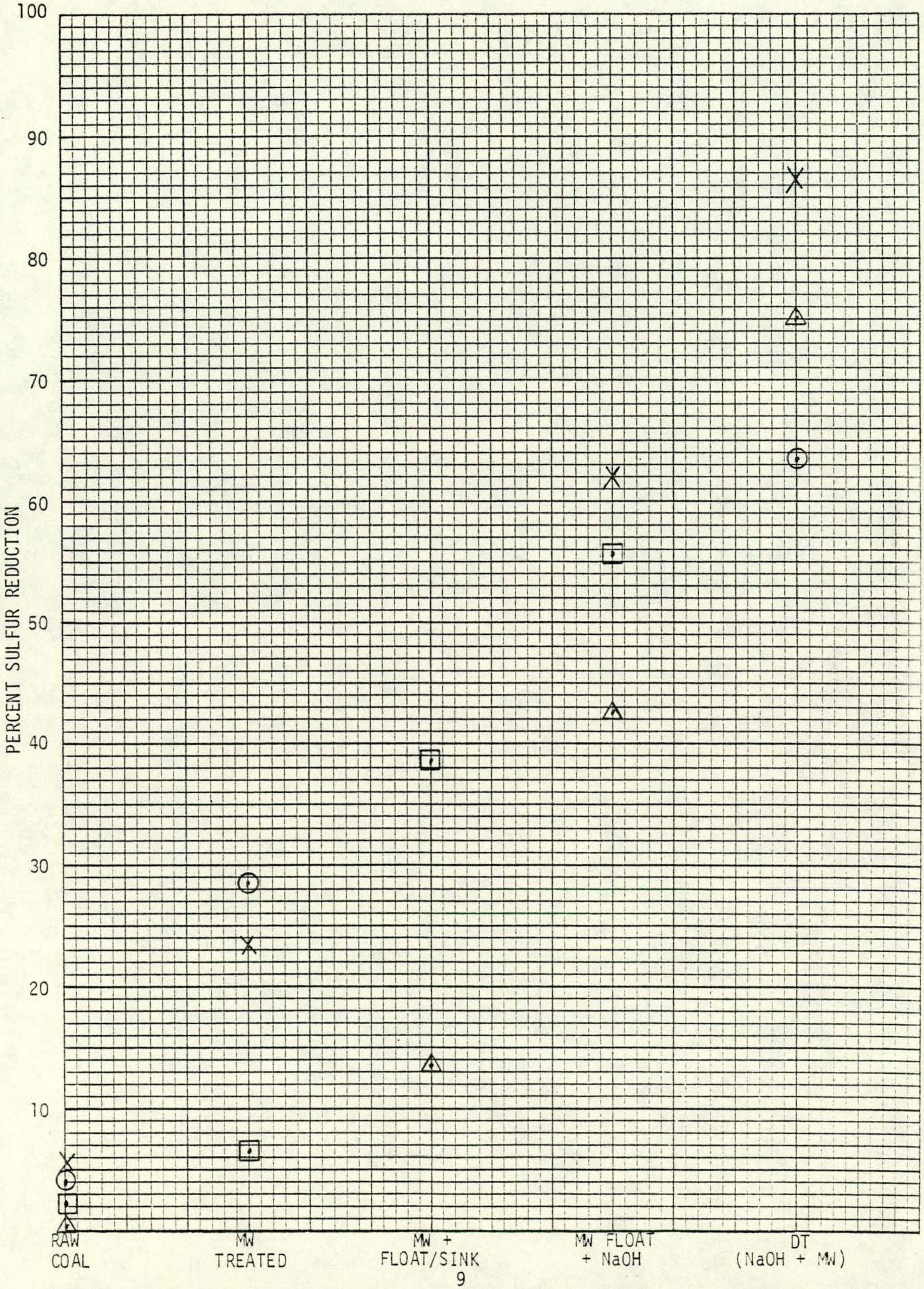
Detailed sulfur reduction histories accomplished by the various steps are shown in Figures 1 through 4.

In previous work, NaOH was added to the coal sample from a water solution and then vacuum dried to 20-30% water level to optimize coupling to the microwave field. This method worked quite well but was time consuming. A new technique is now being used. The coal sample is mixed with NaOH powder, then water is added ($\sim$ 25 wt % $H_2O$) to the powdered mix. The sample is now ready for exposure to microwaves.

FIGURE 1. SULFUR REDUCTION HISTORY FOR PSOC-255

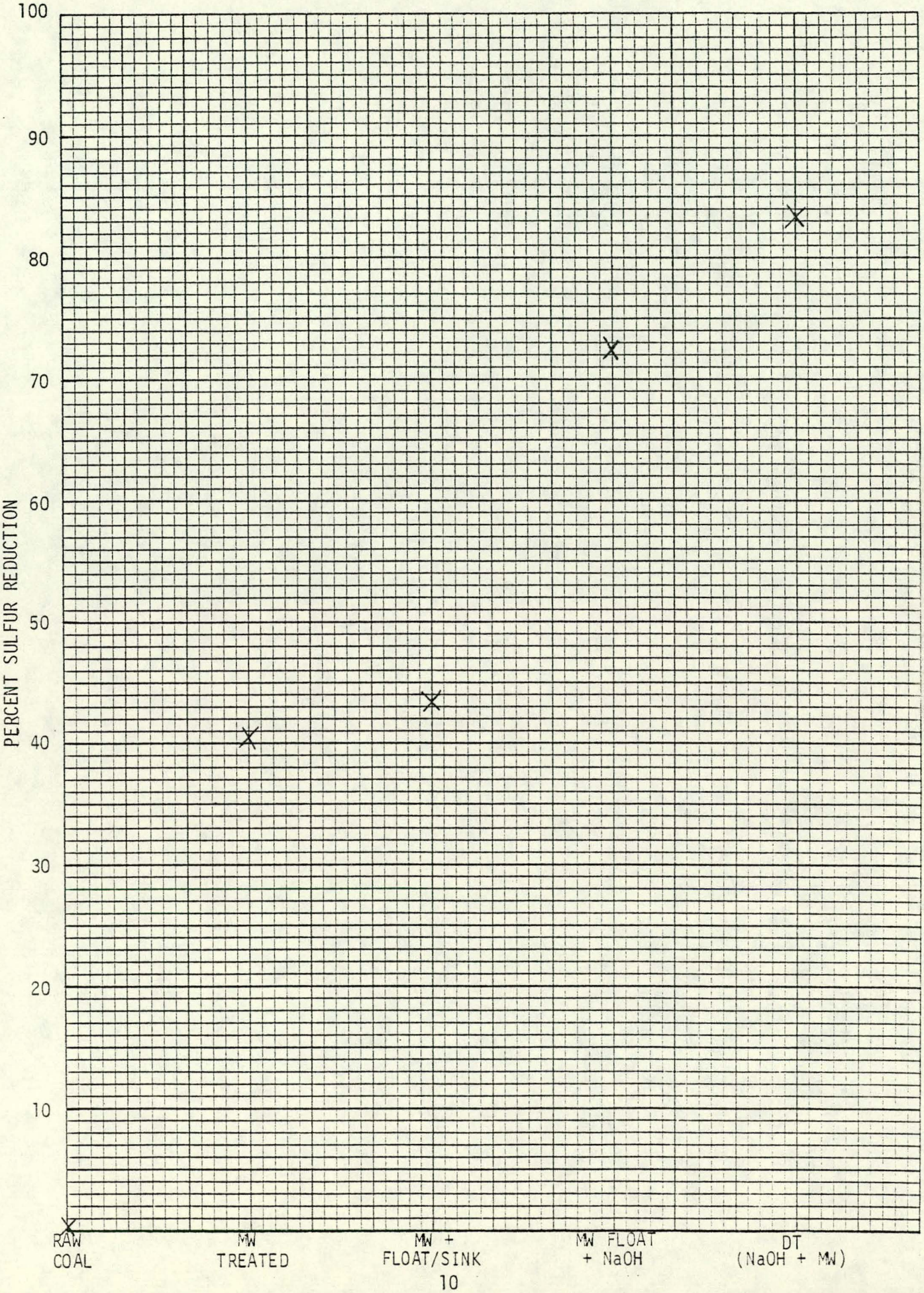
70X100 1/10 Inch Divisions
GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., U.S.A.
FN-521-A (8-50)

FIGURE 2. SULFUR REDUCTION HISTORY FOR PSOC-345



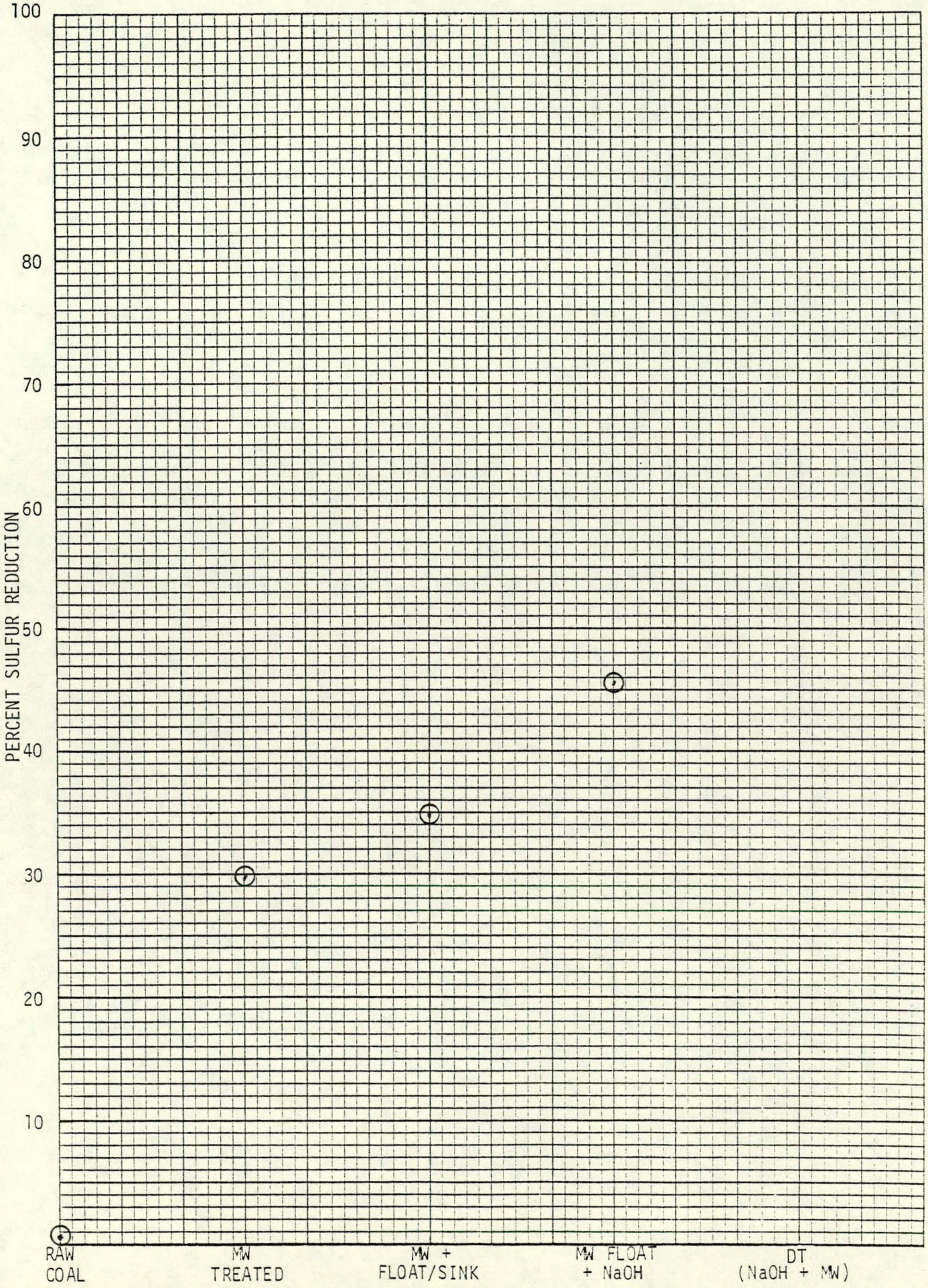

70X100 1/10 Inch Divisions
GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., U.S.A.
FN-521-A (8-50)

FIGURE 3. SULFUR REDUCTION HISTORY FOR PSOC-270




70X100 1/10 Inch Divisions
GENERAL ELECTRIC COMPANY, SCHENECTADY, N.Y., U.S.A.
FN-521-A (8-50)

FIGURE 4. SULFUR REDUCTION HISTORY FOR PSOC-272




70X100 1/10 Inch Divisions
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FN-521-A (8-50)